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Sludge - Recycling for Agricultural Use

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SLUDGE

Recycling For Agricultural Use

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This brochure was prepared for the U.S. EPA Office of Water Program Operations as one of a series of reports to help supply information concerning current practices that are emphasized by the Clean Water Act (CWA) involving the utilization and recycling of municipal effluents and sludges. The series will provide planners, designers, municipal engineers, environmentalists and others with available information on topics of major interest and concern related to municipal wastewater treatment and sludge management options. An effort will be made to provide the most current state-of-the-art information available concerning sewage and sludge processing and disposal/utilization alternatives, as well as costs, transport, and environmental and health impacts. The mention of trade names of commercial products does not constitute endorsement or recommendation for use.

This report provides an insight into how several communities have successfully developed sludge management programs that involve the recycling of municipal sludge for agricultural use. As stated in the provisions of both the CWA and the Resource Conservation and Recovery Act (RCRA), the Agency encourages the recycling of municipal sludge for many uses, including agricultural use, where good quality sludges and good management practices are employed.

Foreword

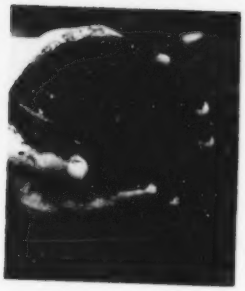
What to do with increasing volumes of sewage sludge is a problem currently being faced by many municipalities. This situation has arisen as a direct result of efforts to clean up our nation's surface waters. The establishment of both Federal and state wastewater treatment requirements and recent initiatives to bring sludge disposal practices under more rigid environmental scrutiny and regulatory control have also been contributing factors.

The recycling of sewage sludge for certain agricultural uses is one alternative to incineration, landfilling and ocean disposal practices that is receiving increasing attention. The potential benefits from recycling the soil-building and nutrient resources in sewage sludge by land application have been well demonstrated and have led to the utilization of sludges in agriculture in many areas.

However, the public doubts and officials' concerns about adding potentially toxic substances and pathogens found in the sludge to productive farmlands must also be carefully considered. Therefore, land application of sewage sludge to agricultural lands must still be examined closely in terms of protection of human health, crop quality and future land productivity.

As a sludge disposal technique, land application of sewage sludge to agricultural lands has been practiced for many years in this country and overseas. Only in recent years, however, have the necessary research and monitoring studies been undertaken to develop sound design guidelines for agricultural use of sewage sludge. Appropriate management practices have been developed to allow land application systems to be properly designed and operated from an environmental standpoint, which also helps assure the long-term productivity and protection of the lands to which the sludge is applied. The various regulations, criteria and guidelines being developed under the authorities of the Clean Water Act, the Resource Conservation and Recovery Act, and other recent environmental legislation will help provide the mechanisms to better control the implementation of agricultural recycle projects as well as other sludge management alternatives in the future.

While this alternative is faced with potential public acceptance and environmental impact concerns, sludge management projects that recycle sewage sludge for agricultural use can, in many cases, be designed and operated to be both cost-effective and environmentally acceptable. This is especially true for small communities which have high quality sludges and are located in areas where adequate farmland is readily available. The implementation of improved industrial pretreatment programs should help to substantially reduce contaminant concentrations in the sludge produced at many municipal wastewater treatment plants and should further enhance the acceptability of recycling even more sewage sludges for agricultural use.



Composted municipal sludge.

What is Sludge?

And What Do We Do With It?

Sludge is the residue of materials removed from wastewater, sometimes called sewage, during the process of wastewater treatment. Because of its origin and the immense quantities in which it is produced (in excess of 6 million tons of dry solids per year in the United States alone), it represents a major handling problem for many communities. On the other hand, because it is composed of humus, nitrogen, and smaller amounts of phosphorus, potassium and other trace metals, it also represents an opportunity for use as an effective soil conditioner/fertilizer.

Sludge is the residue of materials from wastewater treatment...

Viewed as a resource rather than as a waste, sludge offers significant potential when recycled for agricultural use. Based on late 1979 prices, the nitrogen, phosphorus and potassium value of the United States' municipal sludge production is about $100 million per year.

Sludge Disposal—The Traditional Approach

For decades, the key word in sludge handling has been disposal, generally meaning landfill, incineration or discharge to the ocean. While serving as effective means for dealing with sludge, these disposal practices carry certain inherent disadvantages, mainly in regard to the environment.

Landfill of sludge, a common method of disposal, can pose a threat to groundwaters if the disposal site is not properly located and managed. Even under the best of conditions, existing landfill sites are rapidly being exhausted. In addition, due to increasing land costs and widespread public opposition to creation of new landfill sites, potential new sites are difficult to obtain and use for landfill purposes.

Incineration can greatly reduce the volume of sludge. In the past, this process required tremendous consumption of energy. While newer incineration systems can be designed to recover energy and overcome past problems with excessive fuel requirements, they are generally more suitable for larger communities, which can benefit from economies of scale and can better manage these more complex systems.

Ocean disposal formerly provided coastal cities with an economical sludge disposal system. However, due to concerns over potential impacts to the marine environment, today's ocean disposal practices are being phased out under state and Federal laws and regulations.

With many of the traditional sludge disposal methods limited by land shortages, cost and environmental concerns, some communities have turned from a philosophy of disposal to one of reuse.

Sludge Reuse—An Alternative That Makes Sense

By developing and then implementing carefully planned and managed projects, some communities have been able to realize their goal of achieving an environmentally sound, economical answer to the problem of sludge disposal. They have done so through land application of sludge, which has proven advantageous for such uses as reforestation projects, land reclamation, crop production and parkland development.

Why do such programs work? Mainly because when sludge is spread on land, natural biological systems take over, breaking down the sludge and incorporating its nutrients and organic matter into the soil. This enhances the soil quality while providing a beneficial use for the sludge.

...the concepts have turned from disposal to reuse...

Sludge As Soil Conditioner/Fertilizer

The benefits of recycling municipal sludges for agricultural use are extensive. Not only does sludge application help municipalities by acting as a sludge management technique, it also serves the farmer by improving soil, reducing fertilizer costs and increasing crop yields.

Commercial fertilizers are increasing in price and decreasing in availability; conversely, sludge is increasing in availability and can serve as a valuable soil amendment and fertilizer source. In this sense, sludge is actually a misplaced resource. If properly managed, it can help lower spiraling wastewater treatment costs, lower crop production costs, and conserve diminishing supplies of non-renewable resources such as natural gas, from which many commercial nitrogen fertilizers are manufactured.

Major Concerns Over Sludge Reuse In Agriculture

While the benefits of recycling municipal sludges for agricultural use are well documented, a number of concerns are frequently raised when projects involving agricultural reuse are proposed. Primary among the concerns associated with land application of sludge is the possibility of contaminating the soil with pathogens or toxic substances that may be pres-

ent in the sludge. If accumulation of such contaminants exceeds the soil's ability to accommodate the input, the land could be deteriorated rather than improved, groundwater quality could be degraded, local surface water quality could be impacted due to runoff, or the quality of crops grown could be adversely affected due to crop uptake of the contaminants.

University and government researchers across the country have been developing management practices to prevent problems from occurring as a result of applying municipal sludge to cropland. A number of universities, states and Federal agencies have issued detailed guidance on the proper use of municipal sludge as a soil conditioner/fertilizer. Also, the presence of heavy metals such as cadmium and lead, and toxic organics such as PCBs at varying concentrations in different sludges has led EPA and many state regulatory agencies to develop guidelines and regulations, including the *Criteria for Classification of Solid Waste Disposal Facilities and Practices* (40 CFR Part 257), aimed at limiting the levels of such contaminants in sludges applied to the land. Adherence to the recommendations and requirements that are issued by the agricultural extension programs and regulatory agencies should help assure both safe and effective recycling of municipal sludge for agricultural use. By following carefully planned procedures for dispensing the sludge at predetermined application rates and using good quality sludges, land application projects can be implemented and contamination problems avoided.

Field application vehicle distributing liquid digested sludge on agricultural land.

Sludge being transferred from on-farm holding tank to field application vehicle.

From Treatment Plant To Farm

Components Of A Successful Sludge Reuse Program

Recycling municipal sludges for agricultural use has been tried, tested and demonstrated to be a workable solution for the management of some sludges. By following the available guidance and regulations closely, projects can be established that will be cost-effective and gain regulatory agency approval.

But what does it take to put together a workable sludge/agriculture program—one that is locally acceptable and that benefits both the urban community and the farm community? This question is examined in the following sections—sections that detail how sludge reuse in agriculture has worked successfully for some communities and demonstrate how it may be able to work for your community.

Raw sludge, the direct product of wastewater treatment, is an organic/inorganic material containing live microorganisms—bacteria and pathogens, including some that can cause disease or produce objectionable odors. Obviously this is a material that would usually not be suited for direct application to agricultural land.

Lacking proper treatment of sludge, a reuse program would be impossible. Raw sludge should undergo processing designed to stabilize it and produce a material that is safe to use and that will not create odor problems.

Treatment Processes

The most important step in this necessary processing is one of stabilization to make the treated sludge less odorous and reduce the pathogenic organism content. Stabilization can be accomplished in a variety of ways, including composting, heat treatment, digestion and other processes. Among stabilization processes, digestion is the most widely used. During digestion, malodorous organic material contained in sludge is decomposed through bacterial action. In this respect, digestion is similar to composting, which can also be used to stabilize raw sludge.

The most important step is stabilization.

Stabilization processes achieve two important results, both of which are critically necessary prior to land application of sewage sludge. First, stabilization breaks down unstable, rapidly decomposable constituents (principally organic matter) into smaller quantities of more stable organic compounds that, when properly used in agriculture, will not give rise to offensive odors. Secondly, stabilization processes can achieve high degrees of destruction of pathogenic organisms that are present in raw sludge, thus rendering the stabilized sludge much safer for use from the standpoint of disease transmission.

In addition to stabilization, sludge may be partially or nearly completely dried to reduce its moisture content. Whether or not these additional drying steps are employed is largely dependent on the manner in which the stabilized sludge will be used. Sludge may be applied to agricultural land in either a liquid or a dried form.

Public Education Programs

Reuse of sludge through land application requires that the community where the sludge will be applied be assured of the safety and value of the program. In addition, either the municipality must purchase land to use for sludge application or the local farmers must agree to use the sludge. Therefore, a municipality pursuing a program of sludge reuse must work toward public acceptance of the concept and must locate farmers interested in using the sludge product.

Education in the form of public meetings and public information campaigns is the way that many programs have approached community relations. Letting people know and see what to expect—the disadvantages as well as the advantages—helps the communications process and gains public confidence.

Public education and awareness are essential.

An extension of the public education program has been employed to let the farming community know what it has to gain from using the sludge product. This can take the form of small-scale demonstrations where side-by-side comparisons are made on adjoining plots of land to compare crop yields both with and without sludge application. Such demonstrations, when properly carried out (often through university cooperative extension programs), can do much to foster the acceptance of agricultural reuse of sludge by both the urban community that produces the sludge and the farming community that can use it. They have also been an effective way of demonstrating the overall cost-effectiveness of recycling municipal sludge for agricultural use in many locations. This was clearly the case for the agricultural reuse projects developed by Salem, Oregon, and Madison, Wisconsin, described on the following pages.

BIOGRO

A well-conceived and implemented public education program, as well as a project plan that is acceptable to the regulatory agencies, can make the difference between failure and success. This is what Salem, Oregon, discovered as it attempted to find a solution to its sludge disposal problem.

Salem, Oregon, is an important food processing center. While this means that the local economy is thriving and growing, it also means that the city, with a population of 89,000, experiences periodic increases in its waste loads—increases of up to sixfold during the months when canning and freezing operations are in process.

Construction of the Willow Lake Wastewater Treatment Plant in 1964 and its subsequent expansion in 1976 increased treatment capacity to handle peak flows during the food processing season as well as normal loadings during the balance of the year. However, the sludge disposal problem was not solved by increasing treatment capacity.

Sludge Reuse History

Salem continued to discharge sludge into storage lagoons until 1968, when the lagoons were within a few years of reaching their capacity. The city then began to haul sludge to local farmland, where it was applied by a 1,400-gallon tank truck. Unfortunately, the truck tended to become mired in the fields during western Oregon's long rainy season. This made for an inefficient operation because truck turnaround times were greatly increased, the trucks having to be dislodged from the fields and put back into service, and the trucking operation caused undesirable ruts in the cropland. Furthermore, local residents mistakenly blamed the sludge operation for odors originating from other operations involving the disposal of livestock manure. Soon it became difficult to find farmers willing to use the sludge; this led Salem to reevaluate its program and its system.

Salem's BIOGRO Program

As a first step, a trade name and an identifiable logo were developed for Salem's sewage sludge and the city set about promoting its new product, BIOGRO. A program manager familiar with local farming and fertilizing methods was put in charge. With his background and understanding of the program, he could relate easily to the farmers and help them make the best use of BIOGRO. Meetings were held to familiarize prospective users with the program and to obtain their comments on the program. Also, a promotional brochure was prepared and distributed detailing the benefits of BIOGRO and explaining how the program works.

As part of the program revision, transportation of BIOGRO to the farms was improved. To correct the problems encountered during wet seasons, the city limited delivery of large quantities of BIOGRO to the drier months.

The flow rate at Salem's Willow Lake Wastewater Treatment Plant averages 28 million gallons per day (mgd). Because of the large input of food processing waste and the absence of other significant industrial input, sludge production and quality are very high, averaging 7,800 tons per year of stabilized BIOGRO at a 2 percent to 3 percent solids concentration. This sludge product contains useful quantities of primary and micronutrients that are essential for healthy plant growth.

Application of BIOGRO to the farmland is accomplished using 2,500-gallon truck spreaders equipped with special high flotation tires to minimize soil compaction. These spreaders, easily identified by the BIOGRO logo, dispense BIOGRO in a 10- to 30-foot-wide swath by pumping at low pressure. A typical application requires about five tankloads of liquid BIOGRO to produce the equivalent of two dry tons of stabilized sludge per acre of land.

Public education has played an important role in alleviating the confusion about odor and BIOGRO. People in the area now know that BIOGRO has an odor similar to that of tar or used engine oil, not sewage or animal manure. This odor disappears rapidly after application and can be avoided by disking BIOGRO into the soil. Therefore, BIOGRO is no longer blamed for objectionable odors from other sources.

Other considerations involved in BIOGRO use are its relatively low potash content, potential inhibition of seed germination due to initially high levels of ammonia and salts, and viable seeds of unwanted plants such as tomatoes and melons, which are frequently contained in the stabilized sludge. These problems can be overcome by adding supplemental potash fertilizer, planting of seeds at least one week after application of BIOGRO, and normal cultivation practices for weed control.

An intensive program of monitoring and recordkeeping has further convinced both farmers and local residents of the safety of BIOGRO use. This information is valuable to the farmers, who are able to keep track of crop performance, and to the concerned regulatory agencies responsible for preserving the quality of crops, groundwater and the soil.

On an overall basis, then, BIOGRO has been accepted as a safe, effective fertilizer supplement and has been

welcomed by the farmers of the Salem area. In addition, after five years of consistent use and careful testing of sludge, soils, crops and groundwater, no harmful or undesirable effects associated with the use of BIOGRO have been found.

BIOGRO As A Solution

For the city, application of BIOGRO to cropland is not the total answer to sludge management. The growing season in the Salem area ranges from 160 to 210 days per year. While mean temperatures are mild, averaging 45° F during the winter or rainy season, the six-month-long (October through March) rainy season means that there will be times when BIOGRO cannot be applied and must, therefore, be stored. Digesters employed for stabilization at Salem provide 60 days' storage to meet this need; an additional 100 days of emergency storage is available in sludge lagoons.

Initial reaction to BIOGRO and the accompanying program was enthusiastic—so much so that, at times, there was a BIOGRO shortage when demand surpassed supply. Due to present equipment availability and recent large increases in sludge production at Salem, it is difficult to transport and apply all of the current sludge production to farmland on a timely basis. No lack of demand for BIOGRO exists, however, and the problem can be readily solved through the purchase of additional transport and application equipment.

Only a few short years ago, Salem, which at that time had less than half as much sludge to deal with as they have today, was looking at a major sludge disposal problem. Today, through a cooperative effort involving both the city and local farmers, what used to be thought of as a waste product has been transformed into an asset which, used in an economically and environmentally sound way, benefits the entire area. This, perhaps, is the true measure of BIOGRO's success.

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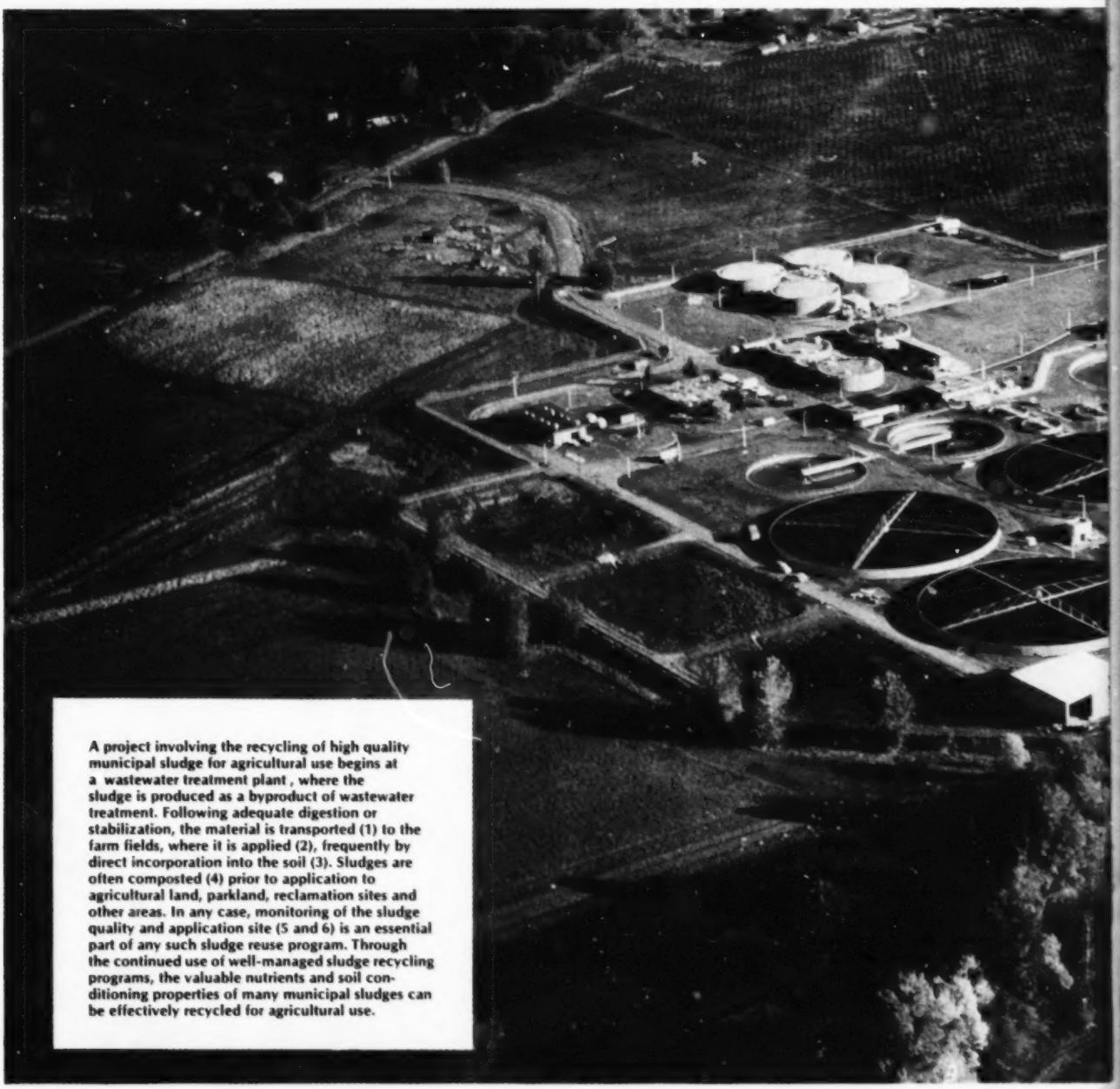

A project involving the recycling of high quality municipal sludge for agricultural use begins at a wastewater treatment plant, where the sludge is produced as a byproduct of wastewater treatment. Following adequate digestion or stabilization, the material is transported (1) to the farm fields, where it is applied (2), frequently by direct incorporation into the soil (3). Sludges are often composted (4) prior to application to agricultural land, parkland, reclamation sites and other areas. In any case, monitoring of the sludge quality and application site (5 and 6) is an essential part of any such sludge reuse program. Through the continued use of well-managed sludge recycling programs, the valuable nutrients and soil conditioning properties of many municipal sludges can be effectively recycled for agricultural use.

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METROGRO

Some 1,700 miles east of Salem is another state capital—Madison, Wisconsin, population 173,000, almost twice that of Salem. In Madison, the winters are longer and harsher than in Salem (the average mean winter temperature is 24° F) and the growing season is about a month shorter. There, snow cover during the winter months is common, and the ground normally remains frozen until mid-March, whereas in Salem snow cover and frozen ground conditions are rare. But in some ways, these two cities are alike. Both have a history of sludge reuse, and both now have highly successful recycling programs in operation.

In Madison, Wisconsin, sludge reuse dates back to the early 1930s, when dewatered digested sludge was sold or given to the public for fertilizing lawns and gardens. The manpower shortage created by World War II meant that this reuse program had to be abandoned in favor of low-cost, low-maintenance storage lagoons. However, in the early 1970s, these storage lagoons experienced a number of dike failures that convinced the city that a more reliable method of sludge disposal had to be found.

Studies And Decisions

Several studies carried out between 1971 and 1974 helped Madison determine that land application of liquid digested sludge would be a possible answer to their sludge disposal problem. In comparison to other methods of sludge handling—incineration, composting and mechanical dewatering—land application was shown to be more economical and more feasible from both technical and environmental standpoints.

One of Madison's major decisions in pursuing a land application program involved selection of the type of land to be used. Should the city operate its own agricultural site or distribute the sludge to local farms?

Reuse by farmers can have advantages over a municipally owned system.

The main advantages of using city-owned land were identified as ready access to and complete operational control of a reliable sludge disposal site. The potential disadvantages for Madison included costly purchase of a large amount of land; the need to condemn and, therefore, remove from the tax rolls existing farmland owned by local farmers for generatjons; and competition with the local farm community through marketing of crops.

The disadvantages of public ownership of land far outweighed the potential advantages; so Madison decided to try to market its sludge to area farmers.

Madison's METROGRO Program

The flow rate at Madison's wastewater treatment plant averages 35 mgd, producing almost 5,500 tons per year of stabilized sludge. Almost 15 percent of the total influent organic loading at the plant is from meat processing and packing operations. Madison's wastewater is therefore high in protein, and the resultant sludge is attractive as a soil supplement because of its organic and mineral contents.

Much like its counterpart in Salem, Madison's program incorporates public meetings, efficient delivery systems, intense monitoring and recordkeeping. Madison even has its own trade name for its sludge product—METROGRO. One big difference between the two programs, however, is the effect of weather. Madison's winters result in frozen ground to a depth of 20 inches from mid-December through mid-March. This means that the sludge application period in Madison is limited. Their equipment cannot effectively operate on wet or soft soil that occurs in late spring and early fall, and the sludge is not applied to snow-covered ground.

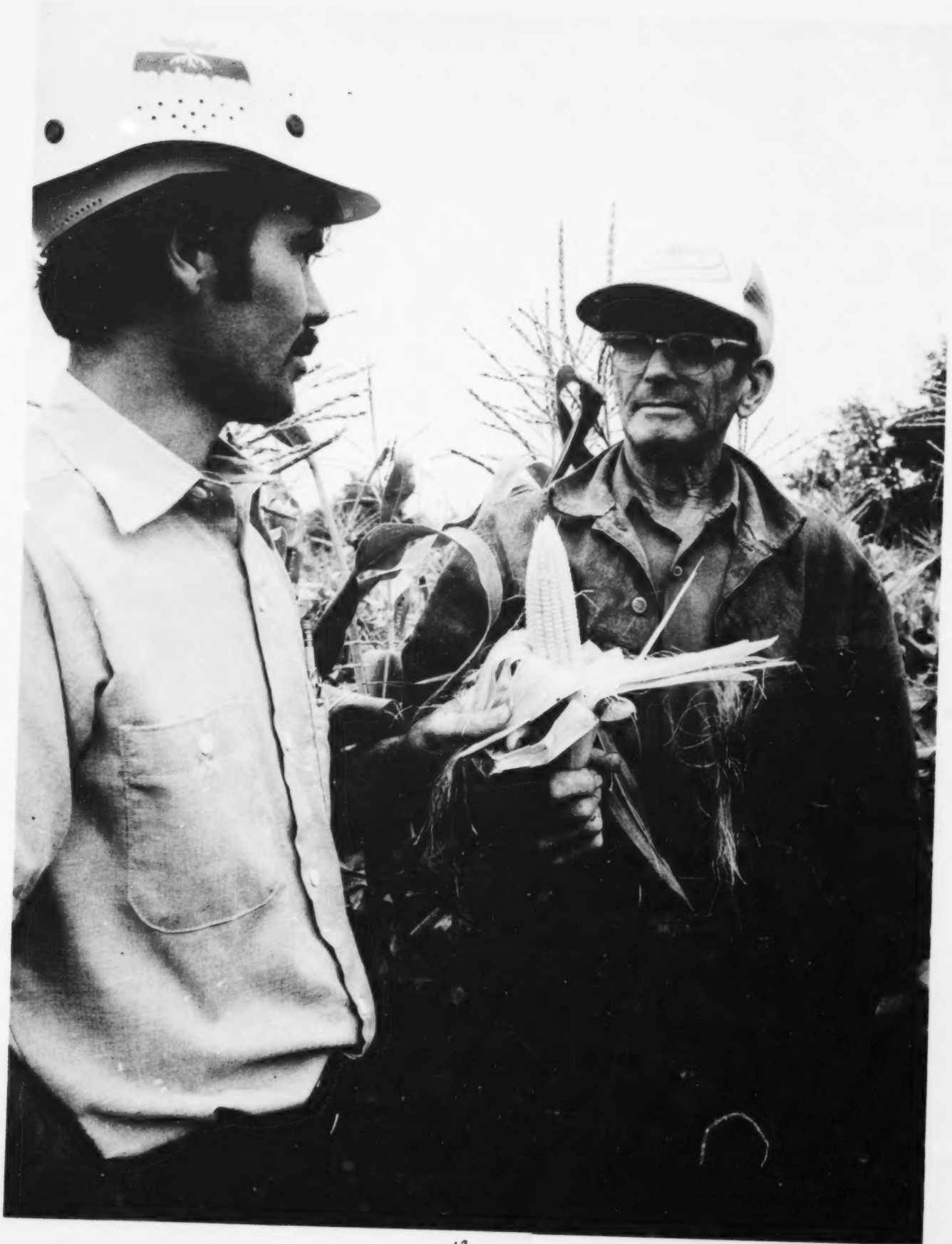
Like Salem, provisions for storage at Madison have solved this problem. One of the city's lagoons is used for temporary storage; therefore, even though sludge production continues throughout the year, Madison's program is not jeopardized by the seasonal periods when sludge application is difficult.

METROGRO is distributed in the Madison area by 3,500-gallon application vehicles equipped with flotation tires. These truck spreaders apply METROGRO on the soil surface or inject it below the surface. Madison supplies all of the labor and equipment needed to dispense the METROGRO; everything necessary to make the METROGRO program a success has been made part of Madison's effort.

The return on Madison's investment of time and planning has been a program that works...a program that links city and farm in the cycle of nature.

Injectors used at Madison place METROGRO beneath the soil surface.

metrogro



Organic solids reuse manager (left) for Madison's reuse program discussing crop performance with a Madison-area farmer who uses METROGRO.

Before deciding on the specifics of its own land application program, Madison reviewed the state-of-the-art of sludge reuse as demonstrated by existing programs in the United States and Great Britain. What Madison learned supported their plan to initiate such a program and provided some of the facts needed to determine how best to approach the overall planning process.

Below is an overview of two of the programs Madison investigated along with an update on the present direction of sludge reuse programs.

Great Britain

The program developed by the West Hertfordshire Main Drainage Authority in Rickmansworth, Great Britain, has been an important pioneering effort in sludge reuse. It wasn't always so, however. A 1,200-acre demonstration project sponsored by the Authority failed to gain farmer acceptance of sludge as a fertilizer until the Authority decided to develop a marketing program.

The marketing program was geared toward improving public relations. Included were creation of a trade name for the Authority's product, HYDIG; publication of a pamphlet describing HYDIG and its uses and benefits as a fertilizer; institution of an extensive monitoring program; emphasis on clean, efficient trucking and spreading services; and reshaping of the image and function of the HYDIG truckdrivers, who are expected to assist the farmer while acting as ambassadors of the Authority. In addition, an advisory board of farmers was established by the Authority to help develop policies and set charges for the landspreading service.

These public relations elements resulted in a successful program, one that enabled the Authority to manage all of its sludge by application to privately owned farmlands while realizing a savings of about 75 percent over the cost of ocean disposal, which still remains the major means of sludge disposal in Great Britain.

Sludge application to agricultural land has also been extensively utilized elsewhere in Great Britain and in other countries such as France, Germany, Sweden and the Netherlands.

Los Angeles County Sanitation Districts, California

A different approach to sludge reuse has been used to market some of the digested sludge resulting from wastewater treatment provided by the Los Angeles County Sanitation Districts. In this major population center, in excess of 100 tons of solids per day are composted after stabilization by digestion. The compost thus produced is sold to a local fertilizer company that further processes the material through screening and blending. The material is then bagged and marketed as a fertilizer and is widely used for home garden and horticultural purposes as well as commercial nurseries. Demand for the product is so high that the fertilizer company has to allocate it to selected customers. This sludge-derived product has been marketed to the public for over 50 years by this same firm.

Current Sludge Agricultural Reuse Programs

In addition to the BIOGRO and METROGRO programs described for Salem and Madison, a large number of other agricultural reuse programs are now in use in many parts of the United States, especially in the smaller towns of the Midwest. Agricultural reuse programs are currently being used or evaluated by large cities—such as Philadelphia, Pennsylvania; Washington, D.C.; Chicago, Illinois; Columbus and Toledo, Ohio; and Denver and Boulder, Colorado—as well as by smaller towns such as Binghamton, New York; Effingham, Illinois; Manhattan, Kansas; and Little Falls, Minnesota.

It is estimated that well over 25 percent of the nation's sewage sludge is presently utilized in land application projects and that most of these projects involve application to cropland. As the costs of alternative sludge management practices continue to rise and sludge quality improves through more intensive implementation of pretreatment programs, even more agricultural reuse programs can be expected to be developed.

The Facts

Operating And Performance Features Of Sludge Reuse

The scope of a particular sludge reuse program will determine the equipment and personnel needs and, therefore, the costs of such a program. A major factor in determining the scope is the quantity of sludge that has to be treated, transported and distributed. The quality of sludge is another important factor. If the sludge is the product of a highly industrialized area, it may contain undesirable chemicals which will require more advanced treatment and a greater degree of monitoring at the application site, meaning higher system costs. Some sludges may actually be unsuitable for agricultural use due to excessive levels of organic chemicals or heavy metals.

Quantity and quality of sludge are critical factors...

The costs also depend greatly upon the distance sludge must be transported prior to application and the type of equipment selected for dispensing the sludge product. Truck spreaders, movable big-gun sprinklers, portable sludge pumps, tank trailers and large "nurse" supply tanks are possible components of a program's equipment list. The choice of specific equipment largely depends on local soil characteristics, the relative size of the overall program and the preferred distribution method of local farmers.

Personnel requirements again depend on the equipment used and the project scope, but generally include a program manager, clerical assistants, equipment operators, monitoring personnel, laboratory technicians, and an assortment of seasonal and part-time employees for peak demand periods.

Program Statistics

The BIOGRO and METROGRO programs provide some operating statistics that may serve as basic guidelines for other municipalities.

Salem's BIOGRO program produces approximately 7,800 tons of stabilized sludge per year. This is equivalent to over 62 million gallons of liquid sludge at a concentration of 3 percent dry solids. A team of three tanker trucks delivers the liquid sludge to farms for use on about 2,000 acres of cropland.

In Madison, stabilized sludge production averages only 5,480 tons per year. This digested sludge is being added to the storage lagoons, which contain approximately 100,000 tons of stabilized sludge produced prior to the METROGRO program. A 10-year program to remove the stored sludge is planned, with 10,000 tons per year to be distributed to some of the 10,000 acres of suitable farmland available within 10 miles of the treatment plant. As the program expands and the lagoons are cleaned out, the city's annual sludge disposal needs will fall to about half the present level. What this means for Madison is that, as the program proceeds, operation costs, equipment needs and personnel requirements will actually decrease.

Differences and similarities in operating costs, system components, monitoring efforts and sludge product constituents for BIOGRO and METROGRO are outlined in the accompanying tables.

Comparison of Annual Costs for Agricultural Application of Stabilized Sludge[1]

BIOGRO (Salem) (Data for the year 1978)		METROGRO (Madison) (Data for the year 1979)	
Application Data		**Application Data**	
Volume—26,345,000 gallons		Volume—7,554,000 gallons	
Solids content—2.6 percent		Solids content—4.0 percent	
Dry weight—2,856 tons (dry basis)		Dry weight—1,260 tons (dry basis)	
Equipment Utilized[2]		**Equipment Utilized**	
4 tank trucks		4 tank trucks[3]	
2 field application vehicles		2 field application vehicles[4]	
1 "big-gun" sprinkler		2 "nurse" tank trailers	
		1 lagoon dredge[3]	
Cost of Program		**Cost of Program**	
Equipment "rental"	$ 72,400	Amortization of owned equipment at 10%/yr.	$ 14,000
Operation and maintenance	$ 73,600	Equipment rental	$ 50,000
		Operation and maintenance	$ 56,000
Total Annual Cost	$146,000	Total Annual Cost	$120,000
Cost per ton of stabilized sludge applied to agricultural land	$ 51.12	Cost per ton of stabilized sludge applied to agricultural land	$ 95.24[5]

[1]Reported costs are for transport and application of stabilized (digested) sludge. Costs of sewage treatment and sludge digestion are excluded.

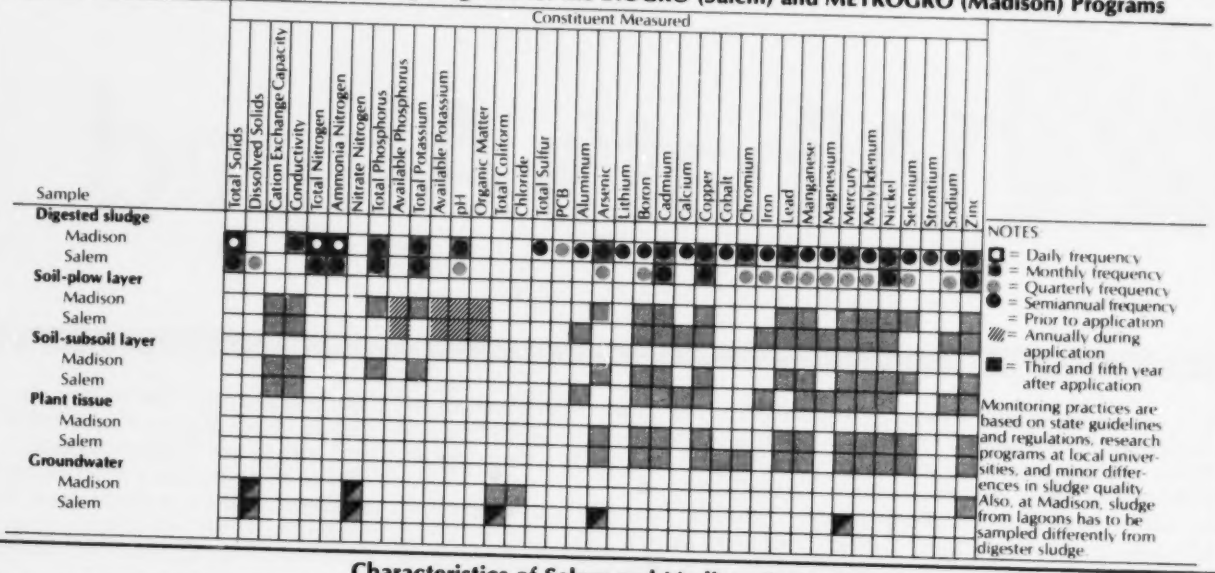
[2]Salem costs are based on equipment owned by the city but "rented" to the BIOGRO program. Rental cost reported is for 84 hr/month operation; additional operating time charged at $15.69/hr for tank trucks and $15.71/hr for field application vehicles.

[3]Madison leased 4 tank trucks and 1 lagoon dredge in 1979.

[4]Owned equipment operated in 1979—original cost = $142,000; 10%/yr = $14,000/yr.

[5]Cost/ton reflects limited quantity of solids applied during 1979; in future years, economies of scale will reduce the average cost/ton.

Comparison of Testing/Monitoring Programs for the BIOGRO (Salem) and METROGRO (Madison) Programs



Monitoring practices are based on state guidelines and regulations, research programs at local universities, and minor differences in sludge quality. Also, at Madison, sludge from lagoons has to be sampled differently from digester sludge.

Characteristics of Salem and Madison Systems

Characteristic	Units	BIOGRO (Salem)	METROGRO (Madison)
Treatment Plant			
Avg. annual flow rate	million gal/day	28	35
Current avg. annual raw sludge	tons/yr—dry matter	12,000 (est.)	9,490
Current avg. annual stabilized sludge	tons/yr—dry matter	7,800 (est.)	5,480
Stabilization/Storage			
Anaerobic digesters	cubic feet	1,007,654	390,000 (addn'l 420,000 under const.)
Storage lagoons	cubic feet	699,000	8,020,000
Transport/Application			
Highway tanker trucks	number/capacity	3 @ 6,000 gal; 1 @ 2,500 gal	4 @ 5,500 gal (addn'l 2 @ 5,500 gal ordered)
Field application vehicles	number/capacity	2 @ 2,500 gal	2 @ 3,800 gal (addn'l 1 @ 3,800 gal ordered)
Field "nurse" tank trailers	number/capacity	none	2 @ 12,000 gal (addn'l 1 @ 12,000 gal ordered)
Lagoon dredge	number/capacity	none	1 @ 1,000 gal/minute ordered
"Big-gun" sprinkler	number	1	none
Application acreage	acres	2,000	600 in 1979 (addn'l acreage available)
Stabilized sludge application rate	tons/acre/yr—dry matter	2	2.1 (range 1.2 to 2.5)

NOTES: 1. Madison has approximately 100,000 tons stabilized sludge stored in lagoons from years prior to institution of the METROGRO agricultural program; hence, their equipment needs are dictated by stored sludge plus current production. A 10-year program to remove stored stabilized sludge is planned.

2. Salem has insufficient equipment to utilize all current sludge production through their BIOGRO program.

Typical Stabilized Sludge Product Analyses of Salem's BIOGRO and Madison's METROGRO

Constituent	BIOGRO (Salem) Concentration (mg/kg)	BIOGRO (Salem) Percent of solids by weight	BIOGRO (Salem) lb/acre added in a 2 dry ton/acre application	METROGRO (Madison) Concentration (mg/kg)	METROGRO (Madison) Percent of solids by weight	METROGRO (Madison) lb/acre added in a 2 dry ton/acre application
Humus	500,000	50.00	2,000	500,000	50.00	2,000
Primary Nutrients						
Total nitrogen as N	99,000	9.90	396	105,000	10.50	420
Available nitrogen as N	18,750	1.88	75	37,500	3.75	150
Phosphorus as P	7,500	0.75	30	14,000	1.40	56
Potash as K	250	0.03	1.0	7,500	0.75	30
Secondary Nutrients						
Calcium as Ca	18,750	1.88	75	51,000	5.10	204
Magnesium as Mg	12,500	1.25	50	9,000	0.90	36
Soluble Sulfate as S	2,000	0.20	8.0	325	0.03	1.3
Micronutrients						
Boron (hotwater soluble) as B	2.5	—	0.01	300	0.03	1.2
Copper as Cu	300	0.03	1.2	525	0.05	2.1
Iron as Fe	22,500	2.25	90	8,750	0.88	35
Manganese as Mn	200	0.02	0.8	200	0.02	0.8
Molybdenum as Mo	15	—	0.06	10	—	0.04
Zinc as Zn	2,000	0.20	8.0	2,350	0.24	9.4
Other Metals						
Cadmium as Cd	20	—	0.08	32	—	0.13
Lead as Pb	410	0.04	1.6	371	0.04	1.5
Mercury as Hg	1.5	—	0.006	16	—	0.06
Nickel as Ni	29	—	0.12	79	0.01	0.32
Chromium as Cr	38	—	0.15	272	0.03	1.1
Arsenic as As	0.1	—	0.0004	9.0	—	0.04

What's Ahead

All over the country, people who have implemented properly managed sludge reuse programs are enthusiastically talking about their successes... and many municipalities listening to these comments are pursuing similar programs of their own. These people who have been directly involved in sludge reuse programs can attest to the benefits that have been realized by the agricultural community and the municipality when good quality sludge is recycled.

Some people, like Jim Cunningham, who has been Organic Solids Reuse Manager for Madison's METROGRO program since it began, talk about the effectiveness and economics of reuse. "From our viewpoint," he explained, "the use of METROGRO is a really successful way of recycling nutrients back to soil. For our sludge and our situation, it is by far the cheapest way of sludge disposal."

Others speak about the management and flexibility of such programs. "As the METROGRO program is implemented, we see how well-conceived the original plans are. The equipment scheduling and management of the program all stress the flexibility which is necessary to accommodate the needs of the landowners who are interested in using Madison's sludge. The program should serve as a model for many municipalities." So said Gloria McCutcheon, Section Chief, Municipal Wastewater, Bureau of Water Quality, Wisconsin Department of Natural Resources.

The farmers who use a municipal sludge product also talk of its benefits. Said Fred and Bob Uphoff, Madison area farmers who grow corn on 124 acres, "During the past several years, we have used METROGRO on our land and find it has greatly improved the texture and water holding capacity of the soil. It is also a good source of nitrogen. We feel fortunate that we have had access to this good organic fertilizer."

BIOGRO has also had its share of acclaim. People have called it "an excellent supplement to commercial fertilizer" (Gary Clark, Salem area farmer). It has been labeled "an excellent example of how wastewater treatment sludges can be recycled and put to a beneficial agricultural use" (EPA Region X staff). And those involved with BIOGRO have characterized themselves as "a firm believer in the program" (Larry McCaffrey, Salem's wastewater treatment plant superintendent).

But not every program will take the shape of a BIOGRO or a METROGRO. As similar programs develop in other areas, they vary to meet the special requirements of location, economy and type of agriculture. For instance, in Conway, South Carolina, the Grand Strand Water and Sewer Authority is developing a sludge reuse system involving owner-operated farming. By late spring 1981, they expect to be disposing of liquid digested sludge via big-gun sprinklers on their 150-acre site. The Bermuda grass grown there will be sold as forage to the livestock areas northeast of Conway.

So sludge is taking its place as a resource. From coast to coast, municipalities are finding that recycling sludge, whether on private or public farmland, can provide a cost-effective solution to the sludge disposal problem. On the other hand, farmers have discovered the benefits of participating in sludge reuse programs—their fertilizer costs decrease, their yields increase, and their soil quality improves.

Of course, the application of sludge to agricultural and other lands must still be closely examined in terms of protecting human health and future land productivity. The results of continuing investigations of land application and other sludge management alternatives aimed at improving these practices will be incorporated into future changes in regulations and guidance issued by the Federal and state regulatory agencies. However, where projects are carefully planned and managed, those responsible for monitoring the quality of our land, air and water resources have supported sludge recycling to the land for agricultural and other uses as acceptable means for sludge management.

Recycling municipal sludge for agricultural use can help reduce the wastewater treatment burden felt by the cities. In addition, the farmers can benefit by being able to use a formerly discarded, low-cost nutrient source. Finally, in a world of diminishing resources and increasing demands, recycling is a solution that makes sense.

EPA is charged by Congress to protect the Nation's land, air and water systems. Under a mandate of national environmental laws focused on air and water quality, solid waste management and the control of toxic substances, pesticides, noise and radiation, the Agency strives to formulate and implement actions which lead to a compatible balance between human activities and the ability of natural systems to support and nurture life.

If you have questions or desire further information on sludge recycling for agricultural use, they may be directed to your nearest EPA Regional public information office.

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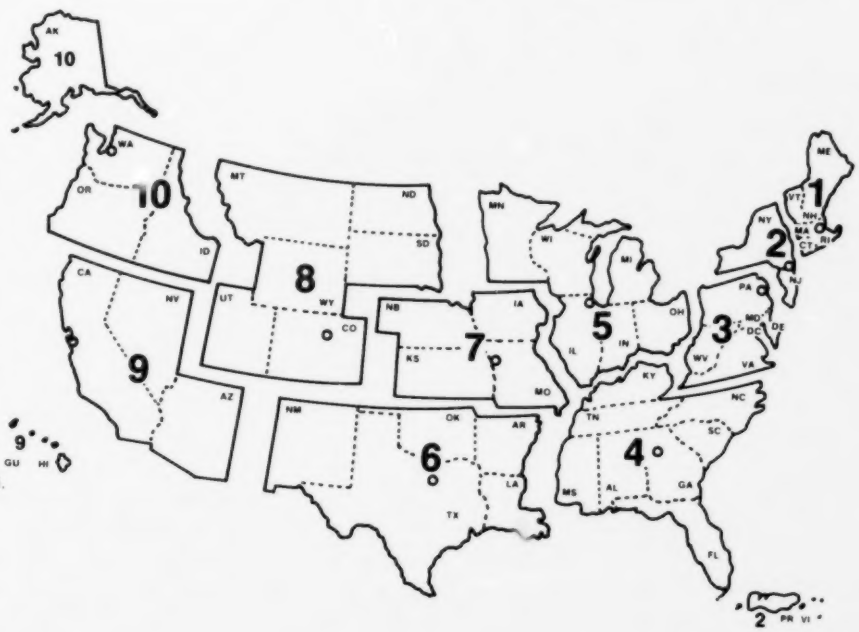

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